

Physical Infrastructure (Indicator 56)¹

Extent to which institutional framework supports . . . Including the Capacity to Develop and Maintain Efficient Physical Infrastructure to Facilitate the Supply of Forest Products and Services and To Support Forest Management.

Rationale and Interpretation

Capital resources that take the form of physical infrastructure are essential to the management of forests and ultimately to economic development and quality of life in rural forested areas. Investments in public infrastructure such as roads, bridges, sewerage and sanitation systems, schools, parks, and other physical facilities are important initiatives of governments which complement the capital investments of private firms (e.g., plants and equipment). Together they constitute the capital basis for protecting forests and related resources and for producing the goods and services that sustain the economies of forested areas (Roundtable on Sustainable Forestry 1999).

Useful data for measuring this indicator are compilations and descriptions of laws and programs at national and subnational levels that promote investments in infrastructure. From a forest resource perspective, useful information includes types and magnitudes of forest infrastructure (for example, campgrounds, roads, trails, signs, fire lookouts, interpretative and educational facilities), forest area judged to be adequately serviced by existing infrastructure and plans for future infrastructure investments, portion of existing infrastructure being managed to designated standards and needs, and the extent to which public and private sector budgets devote financial resources to new works of infrastructure, compared to maintenance of existing infrastructure. Also relevant is the extent to which local, regional, and national inventories of infrastructure are undertaken and the degree to which the information provided from these inventories is relevant to decisions regarding the use, management, and protection of forests. In assessing this indicator, it is important to be aware of measurements that can be interpreted in various ways. For example, while roads are important to most interests in the sustainability of forests, some segments of society consider roads to have a negative impact on the importance of certain forest values (Roundtable on Sustainable Forestry 1999).

¹ Prepared by Paul V. Ellefson, Professor (pellefso@umn.edu), and Calder M. Hibbard, Research Specialist (hibb0006@umn.edu), Department of Forest Resources, University of Minnesota. St. Paul, MN. Draft prepared January 2002. Anonymously reviewed and subsequently revised July 2002.

Concepts and principles that are to be identified and addressed are suggested by the indicator. To guide this review, brief definitions of three important concepts are *physical infrastructure* — underlying large-scale, capital assets (physical and tangible) required in order to use, manage and protect forest resources; *facilitate the supply of* — ability of infrastructure to efficiently expedite the availability of services and products from forests; and *support forest management* — ability of infrastructure to provide for activities considered essential to tending (administering) forests and related resources.

The definition of physical infrastructure as used here does not preclude consideration of various types of infrastructure. For example, physical infrastructure can be inclusive of least four basic elements, namely forest ecosystems as infrastructure, forest land base infrastructure (trails, roads, recreation facilities), processing and manufacturing infrastructure (manufacturing and fabricating facilities), and broad forest community infrastructure (schools, hospitals, highways, libraries, museums, and sanitation systems) that promotes health and safety interests and provide important contributions to the quality of life in towns, cities, and rural areas. Although these categories are not mutually exclusive, they do provide structure for review and assessment of information concerning forest infrastructure.

The infrastructure subject matter to which this review is addressed excludes (but discusses as an issue) the notion that forest ecosystems per se can be considered a form of infrastructure ("green infrastructure"). Such information is presented in great depth in various indicators associated with Criteria 1 through 6.

Conceptual Background

The notion of infrastructure conveys the sense of the basic, underlying framework or features of something. Frequently it is used to refer to features of a technical or structural nature, such as the military installations, communication systems, and transportation networks of an organization, city, or nation. In a geographical context, the infrastructure of a particular locality or region provides the underpinnings of economic and social life for those who live and work in that area. Whether running a business, raising a family, or merely visiting from another region, people depend on -- and to varying degrees, come to expect -- a core framework of services to be available, from roads and communication systems to schools and medical facilities. With such in place, people can pursue the myriad of activities that are the bases of their everyday lives. Unless such basic underpinnings are available, many activities necessary to a well-functioning society, including sustaining forest resources, may not be possible (Fox 1987, Lewis and others 1993, Munnel 1990, Sears and others 1990, U.S. Department of Agriculture 1990, Vanghn 1984).

People who live and work in rural forested areas utilize a variety of resources in pursuing their interests. Some resources are used to provide goods and services that are directly consumed while others are used as a resource in the production of other products (for example, timber as an input to producing wood products). Within such a context, resources can take different forms, including *biophysical resources* (trees, water, wildlife), *human resources* (labor, management skills), and *capital resources* (plants and equipment). The latter are frequently viewed as capital assets directly supportive of manufacturing processes, yet important capital resources also include roads, bridges, electricity, communication systems, health and educational facilities, law enforcement, and fire protection services -- all of which are essential to the variety of productive (and consumptive) activities of a community, region, or State. Although the term *infrastructure* can be applied to all three types of resources, it is usually reserved as a descriptor for capital resources.

The capital resources important to the infrastructure of an area or community may originate from private as well as public sources. From a private perspective, capital can originate from various internal sources (reinvested business revenue) as well as a myriad of external sources (public and private lending institutions). Although private investments in infrastructure are most commonly viewed as *physical capital* (investments in plants, facilities, equipment) required in order to carry out primary production processes, some firms consider capital to include the *human capital* (investments in work-related training, employee health and educational benefits) required to enhance labor and managerial skills, and *community capital* (investments in the establishment and maintenance of community service organizations via donations and sponsorship of events) needed to provide a wholesome and secure community for employees and supportive citizens. In some cases, the financial resources of lending institutions are considered to be capital. These financial resources are made available to private enterprises for a variety of purposes including the establishment of certain kinds of infrastructure that have broader social purposes (for example, pollution control facilities).

The public sector is also a major contributor to infrastructure. Federal, State, and local governments invest revenue (accrued or borrowed) directly (roads, dams) or indirectly (cost-share with private enterprises) in infrastructure as a means of enhancing private sector production and improving the quality of life of individuals and communities in general (Table 1). Government investment in infrastructure is a recognition that even with available private capital, firms, and businesses may need additional investment in infrastructure if they are to be productive and operate efficiently. There must be roads and bridges in place to permit businesses to obtain raw materials and to transport products and services to markets, just as business must have access to facilities that provide electricity, water, wastewater treatment, and communication networks. The magnitude of such investments and the dispersal of their benefits over many firms and communities positions government in a leading and responsible role for their provision.

Public infrastructure investments are often popularly viewed as supportive only of businesses or economic enterprises. In reality, however, such investments focus on a wide variety of social functions considered necessary to healthy and wholesome communities. Public school buildings, for example, are an obvious necessity to a well-functioning educational system. Likewise, police and fire protection services require physical facilities and equipment if they are to provide citizens the opportunity to live and work in an atmosphere of security. And parks and recreation facilities contribute to citizen opportunity to experience the aesthetic dimension of natural surroundings in a relaxed and unconstrained fashion.

Effective and well-functioning infrastructure depends on well-planned investments that are efficient and of an appropriate scale. In this respect, guidance (principles) has been provided for Federal investments in infrastructure (transportation, water resources, energy, environmental protection)(Presidential Executive Order 1994). Infrastructure investment and management should be based on systematic analysis of benefits and costs (consider the full range of options available for accomplishing desired objectives, quantify benefits and costs to the extent possible, discount costs over the full life-cycle of a project, directly and explicitly address project uncertainty), efficient management of infrastructure facilities (sound operational practices, appropriate pricing of services provided), active participation of the private sector (appropriate private sector ownership, financing, construction, operation), and sharing project development with State and local governments (encourage planning activities, development of information management systems).

Table 1. Functional Categorization Scheme for Public Infrastructure by Type of Facilities

Service Facilities	Production Facilities
<p><i>Education:</i> Elementary, middle, secondary schools; public libraries</p> <p><i>Health:</i> Hospitals, nursing homes, ambulatory (outpatient, dental, health), resident facilities (dependent children, emotionally disturbed, handicapped, drug abusers), emergency vehicle services</p> <p><i>Justice:</i> jails and prisons, law enforcement facilities</p> <p><i>Recreation:</i> community recreation facilities</p> <p><i>Transportation:</i> railroads, airports, streets and highways, inter- and intra-community transit</p>	<p><i>Energy:</i> direct power suppliers</p> <p><i>Fire Safety:</i> fire stations, communication systems, water supply and storage facilities</p> <p><i>Solid Waste:</i> disposal sites, collection facilities and equipment</p> <p><i>Telecommunications:</i> cable and satellite television, over-air television, disaster preparation facilities</p> <p><i>Waste Water:</i> sewer mains and collection systems, treatment and disposal systems</p> <p><i>Water Supply:</i> community systems (storage facilities, treatment facilities, delivery systems), onsite wells and cisterns</p>

Source: Vanghan 1984.

Current Institutional Capacity

Private Sector Capacity

Private sources of information describing infrastructure investments of relevance to sustaining forests are few and the amount of information they make available is not very extensive. In many respects, the information originates from many uncoordinated sources, seldom is capable of being compared in any meaningful way, and, because of definition problems and inconsistent time periods assessed, poses real problems for sound analysis over long periods of time. In addition, nearly all the information that is published focuses on wood product manufacturing and processing. With the notable exception of private investments in the infrastructure necessary for water pollution prevention, very little information is devoted to descriptions of infrastructure devoted to other benefits of the forests generally (for example, water, recreation, range, wilderness). Notable in this respect is the void of information about infrastructure that supports outdoor recreation on private forest land (for example, roads, bridges, campsites, shelters) (Teasley and others 1999).

Some private publishers periodically present information that describes the extent of capital assets in certain segments of the wood-based industry, most notably the number of processing facilities (usually referred to as mills) and the number of new or closed manufacturing facilities. Example publishers (or publications) are Miller Freeman Publications², *Business Week* (R&D Expenditures), *Maharashtra Industry Directory*, Wood Science & Marketing (University of Washington), *Forbes* (Annual Report on American Industry) and WoodCenter.net. Information on infrastructure can also be gleaned from the annual reports of individual companies and from a variety of privately sponsored Web sites (for example, Corporate Information at <http://www.corporateinformation.com>; CompanyProfiles at <http://busref.lib.umn.edu/tools/corpro.html>; Kompass Worldwide at www.kompass.com; and Reference-USA at <http://www.referenceusa.com>).

² Miller Freeman directories include Lockwood-Posts's *Directory of Pulp, Paper and Allied Trades*, *Pulp and Paper North American Fact Book*, *Lumber and Panel North American Fact Book*, *Directory of Wood Products Industry*, *Secondary Wood Products Manufacturers Directory*, and *Pulp and Paper Company Profiles* (Volume I-United States, Volume II-Canada).

Table 2. Capital Expenditures in Paper Manufacturing and Wood Product Manufacturing in the United States by Region, 1997, 1998, and 1999

Region	Paper Manufacturing (thousands of dollars)			Wood Product Manufacturing (thousands of dollars)		
	1997	1998	1999	1997	1998	1999
Northeast	1,366,253	1,584,799	1,236,995	238,100	302,123	245,704
North Central	1,973,850	2,113,766	2,059,378	537,222	552,908	645,781
South	4,397,278	3,952,498	3,030,662	1,330,272	1,330,272	1,399,972
West	818,342	818,342	670,345	610,997	610,997	727,105
Pacific	695,790	695,790	594,264	453,730	453,730	602,197
TOTAL	8,55,723	8,492,703	6,997,380	2,812,452	2,796,300	3,018,562

Note: Information is available by State.

Source: American Forest and Paper Association 2000.

Trade associations representing the wood-based industry also periodically publish information regarding plant capacity and capital investments in various types of infrastructure. An example is the American Forest and Paper Association which annually reports capital expenditures for paper and wood product manufacturing, primary mills and converting plants and environmental protection expenditures (Tables 2 and 3) (American Forest and Paper Association 2000). Much of the information reported by the association has been previously published by the U.S. Bureau of the Census.

Although not a private source of infrastructure information regarding wood-based manufacturing establishments and capital investments, Federal government agencies are very active in this respect. Most notable is the U.S. Census Bureau and the U.S. Bureau of Economic Analysis. To the extent that establishments and capital expenditures are reflective of infrastructure conditions, the U.S. Census Bureau's "Economic Census of Manufacturing" and report on "Annual Capital Expenditures" presents a wealth of statistical information by State and industry (Table 4) (U.S. Census Bureau 2001a and 2001b). In some cases, the information is troubled by "failure to disclose" problems, yet such are modest given the comprehensive and long-term series of information presented.

Table 3. Capital Expenditures for Environmental Protection by the Pulp and Paper Industry in the United States by Type of Resource Protected, 1990–2000

Year	Total Investments (millions of dollars)	Environmental Resource Protected (millions of dollars)		
		Water	Air	Land (solid waste)
1990	1,292	579	478	235
1991	1,343	676	479	189
1992	1,048	486	379	183
1993	737	337	275	125
1994	721	286	249	186
1995	625	309	219	97
1996	740	352	251	137
1997	588	325	151	112
1998	627	312	129	186
1999	718	360	290	68
2000	1117	382	657	78

Source: American Forest and Paper Association 2000.

Table 4. Establishments and Capital Expenditure of Wood-Based Industry in the United States by Type of Industry, 1997

Industry	Establishments	Capital Expenditures 1997 (thousands of dollars)
Logging	13,533	780,601
Sawmills & Wood Preservation	4,841	1,161,016
Veneer, Plywood & Engineered Wood Products	1,841	762,558
Millwork, Containers and Other Wood Products	10,685	945,660
Pulp, Paper & Paperboard Mills	546	5,727,647
Converted Paper Product	5,322	2,867,486
Wood Furniture	8,061	255,044

Source: U.S. Census Bureau. 2001a.

Federal Government Capacity

Information regarding Federal authority and institutional capacity to develop and maintain infrastructure is scattered amongst various sources and seldom has as a central focus the importance of infrastructure to sustaining certain forest conditions. As for legal authority to expend appropriated funds on infrastructure, such is seldom specified specifically in statutes addressing forests and related resources. Most often such is specified as part of authority to spend monies generally. For example, the National Trails System Act of 1968 authorizes to be appropriated specific amounts of money for development of certain trails (for example, Pacific Crest National Scenic Trail, Appalachian National Scenic Trail), while the Federal Land Policy and Management Act of 1976 establishes a working capital fund to be used for investments in the management of public lands, including infrastructure investments. Likewise, the Forest and Rangeland Renewable Resources Planning Act of 1974 authorizes the installation of a proper transportation system to service the National Forest System, and the Public Rangelands Improvements Act of 1978 authorizes

investments in infrastructure that will improve Federal rangelands (dams, roads, trails). Unfortunately, a comprehensive review of Federal legal authority focused on infrastructure investments in a natural resource setting has not been carried out.

Federal investments in public works are gathered by the U.S. Bureau of the Census as part of the agency's annual (since 1952) survey of State and local government finances (U.S. Census Bureau 2000a). The definition of public works infrastructure is very broad and indirectly includes investment in natural resources (highways, airports, sewerage, water supply, solid waste facilities, mass transit, water transport terminals). In 1995, Federal expenditures in these activities totaled \$12.8 billion of the \$193.0 billion invested by government (7 percent Federal, 29 percent State, 64 percent local), of which an estimated 39 percent was in the form of capital expenditures. A similar but more natural resource focused dataset specifies Federal government capital outlays in natural resources as \$3.3 billion in 1995 (3.0 in 1994, 6.1 in 1993, 5.5 in 1992, 4.7 in 1990, 4.1 in 1985, and 4.0 in 1980)(U.S. Census Bureau 2000b).

Information about USDA Forest Service investments in infrastructure is similarly defused, although some is publicly available in reports of independent agencies (for example, General Accounting Office 1991) and in the agency's annual reports. For example, in the National Forest System in 1998 the agency was involved in the construction of more than 200 miles of road and reconstruction of more than 2,700 miles of road, construction or maintenance of more than 130,000 miles of trails, and construction or reconstruction of 6 bridges (much of this information is available by State) (Forest Service 1999). A recent but significant change in road infrastructure within the National Forest System has been the decommissioning of roads, which has increased from about 1,500 miles per year in 1996 to about 2,800 miles per year in 1999 (Forest Service 2000). Since 1994 (information is available annually beginning in 1981), the agency's dollar investments in facilities, road, and trails (construction and maintenance) were as follows (Forest Service 1999) (millions of dollars):

Year	Facility Construction	Road & Trail Maintenance		
		Facility Maintenance	Road & Trail Construction	Road & Trail Maintenance
1994	94,437	26,476	130,896	79,180
1995	61,588	26,304	129,655	83,784
1996	46,029	23,008	115,359	81,019
1997	59,974	23,008	115,000	81,019
1998	47,919	24,244	114,951	84,794

Information about infrastructure investments in the National Park System is periodically issued by independent government agencies (for example, General Accounting Office 1995). In addition, the USDI National Park Service provides information on investments in “improvements (and maintenance)” and “construction” (which may or may not be related for forests and related resources). For selected years beginning in 1990, these investments were as follows (USDI National Park Service 2000) (millions of dollars):

Year	Improvements (and maintenance)	Construction
1990	160.0	108.5
1991	179.6	134.1
1992	212.1	193.3
1993	224.8	226.8
1994	222.9	205.6
1995	234.0	192.0
1996	234.0	168.0
1997	246.0	188.0

Table 5. Recreational Infrastructure Data-Base Sets for National Outdoor Recreation Supply Information System by Recreation Provider, 1998

Federal Agencies	Local Agencies
Estate Agencies Multiple-Use Agencies Forest Service Bureau of Land Management Resource Protection and Public Use National Park Service U.S. Fish and Wildlife Service Other Federal Land Resources Indian Land Department of Defense Land Water Resource Agencies Bureau of Reclamation U.S. Army Corps of Engineers Tennessee Valley Authority National Oceanic and Atmospheric Administration Specially Designated Federal Systems National Wilderness Preservation System National Recreation Areas National Trails System National Wild and Scenic Rivers	Municipal Recreation and Parks County Recreation and Parks Special Park Districts Local Recreation Facilities and Sites
	Urban Agencies
	Greenways Rails-to-Trails Land Trusts Tourism Development
	Private Sector
State Agencies State Park Systems in the United States State Park Areas State Park Facilities Other State Resource Systems State Forests State Wilderness State Fish and Wildlife Land State Trust Lands State Scenic Rivers	Recreation Land Nature Conservancy Industrial Timber Lands Private Recreation Businesses Campgrounds Downhill and Cross-Country Skiing Outfitters and Guides Farm/Ranch Vacations Amusements and Attractions Golf and Tennis Facilities Vacation Homes and Resorts
	Public/Private Partnerships
	Scenic Byways Watchable Wildlife

Source: Adapted from Betz 1998.

The National Outdoor Recreation Supply Information System (NORSIS) provides extensive information about recreation infrastructure (Cordell 1999, Betz 1998, Betz and others 1999). Compiled for the 1998 Renewable Resources Planning Act Assessment of Outdoor Recreation and Wilderness, the system organizes information (primarily at the county level) from an extensive variety of references and databases (both public and private). The system presents summary measures of outdoor recreation supply (infrastructure) in terms of area (acres), miles (roads and trails), and number of units (campgrounds), with the information organized by major resource ownership categories (Federal, State, local, and private) (Table 5).

State Government Capacity

State governments' capacity to gather, analyze, and distribute information regarding infrastructure relevant to the use, management, and protection of forests has not been systematically nor comprehensively determined. Such is especially true for information describing the legal authority (capacity) of State government to promote

investments in infrastructure. Some private organizations representing State governments at the national have gathered State expenditure information, some of which has relevance to infrastructure but not specifically forest infrastructure (for example, State general expenditures, Federal direct payments to States)(Council of State Governments 2000).

State capacity to address various elements of forest infrastructure is also provided by a 2000 analysis of State government executive agencies influencing the use, management, and protection of forests. The analysis determined that nationwide in 2000 there were 47 cabinet level entities (departments, agencies, commissions) engaged in economic development and business promotion activities involving investment in infrastructure important to forest conditions. Within this same functional area there was 46 subcabinet (first tier entities) engaged in similar matters. Nineteen governing or advisory bodies to executive agencies also had influence over economic development related infrastructure matters. Also at the department level were six State entities involved in the development of transportation and communication matters involving infrastructure (Ellefson and others 2001 and 2002). This information is available by State and region.

Although not strictly a State government initiative, information about State and local investments in public works are gathered by the U.S. Bureau of the Census as part of the agency's annual survey of State and local government finances(U.S. Census Bureau 2000a). In 1995, State expenditures in these activities totaled \$56.4 billion of the \$193.0 billion invested by government (7 percent Federal, 29 percent State, 64 percent local), of which an estimated 39 percent was in capital assets. Data focused on natural resources specifies 1996 State and local government capital outlays in natural resources as \$2.9 billion (3.0 in 1994, 6.1 in 1993, 5.5 in 1992, 4.7 in 1990, 4.1 in 1985, and 4.0 in 1980) and in parks and recreation as \$4.9 billion (4.1 in 1995, 3.9 in 1994, 3.8 in 1993, 3.9 in 1992, 3.9 in 1990, 2.2 in 1985, and 2.0 in 1980)(U.S. Census Bureau 2000b). This capital outlay information is available by State.

Local Government Capacity

As with State governments, local capacity to gather and present infrastructure-type information directly relevant to forests and forest uses has not been gathered nor assessed. However, local investments in public works are gathered by the U.S. Bureau of the Census (U.S. Census Bureau 2000a). In 1995, local expenditures on these activities totaled \$123.7 billion of the \$193.0 billion invested by government (7 percent Federal, 29 percent State, 64 percent local), of which an estimated 39 percent was in capital assets. The extent to which these investments focus on forest or related natural resources is not known.

Table 6. State and Local Government Capital Outlays for Infrastructure in Forested Counties of Michigan, Minnesota, and Wisconsin by Infrastructure Category, 1986

Major Infrastructure Category	Michigan (percent of capital outlays)	Minnesota (percent of capital outlays)	Wisconsin (percent of capital outlays)
Core Infrastructure (transportation, utilities, sewerage & sanitation)	15	22	26
Education Services (schools & libraries)	57	39	44
Environment (parks, recreation, natural resources)	1	2	3
Social Services(hospitals & health care)	9	4	5
Public Safety (police & fire protection)	3	3	5
Housing & Community Development	*	10	1
Other Capital Outlays	15	29	16
Total Percent	100	100	100
Total Dollars (Thousand Dollars)	\$ 2,384,381	\$ 895,978	\$ 1,940,672

Note: Capital expenditures represent all capital expenditures by all levels of government in a county. Less than 1 percent indicated by “*.”

Source: Lewis and others 1993.

Infrastructure in forested counties located in Minnesota, Wisconsin, and Minnesota was assessed in 1993 using U.S. Census Bureau county government finance and related reports (Lewis and others 1993). The focus was on 1986 capital outlays by all levels of government (local, State, Federal) in rural forested counties, namely counties without large urban centers (populations exceeding 25,000) and whose land area was at least 25 percent forested (45 percent of the counties in the three States were so classified). Of the total capital outlay for infrastructure in 1986, the largest portion was directed to education services (57 percent Michigan, 39 percent Minnesota, 44 percent Wisconsin) with core infrastructure a distant second in level of capital outlay (Table 6). Capital investment in environmental infrastructure did not exceed 3 percent of total capital outlays in any of the States analyzed. Although the information presented here focuses on State level findings of the assessment, the same information is available for each forested county in the three Lake States. A virtue of the assessment was the focus on forested units of government at the local level (namely, counties). Conversely, exactly how the identified infrastructure investments relate specifically to forest sustainability is unknown.

Summary of Conditions

An effective level of infrastructure is important to accomplishing a diversity of societal interests in the sustainability of forests and the communities that depend on them. This review of infrastructure capacity at Federal, State and local levels of government suggests the following:

- Infrastructure is often presumed to exist as a set of conditions facilitating the management of forests, use of benefits provided by forests, and the quality of life of communities that see forests as a community attribute. Unfortunately, infrastructure conditions are often assumed to just exist; most often not being explicitly considered as a foundation that must be invested in and subsequently managed.

- Infrastructure occurs as a result of investments in various conditions, including investments associated with forest resource conditions (forest roads and trails, recreational facilities), processing and manufacturing facilities (particle board mills, pulp and paper mills), and community supporting facilities (schools, highways, sewerage treatment facilities). Determining acceptable levels of investment in public infrastructure is difficult because of the often differing social and political preferences of forest users (for example, forest road systems).

- Legal authority and institutional capacity to affect infrastructure important to forest and community sustainability is distributed among and within many levels of government. In reality, nearly all forest resource agencies exercise some capacity to influence infrastructure, although very few government agencies have explicit responsibility for infrastructure conditions. The closest to concentrated responsibility for promoting infrastructure investments occurs in economic development agencies, pollution control agencies, and in some resource management agencies (for example, road systems, recreation facilities).

- Infrastructure considerations important to forest conditions tend to focus on physical facilities associated with the extraction, processing, and distribution wood and wood products (for example, forest roads, manufacturing mills, highway systems). In terms of visibility, investment levels and available information, lesser concern appears to be focused on the infrastructure necessary to provide other forest benefits (for example, recreation, water, range).

- Infrastructure investments by the private sector are primarily the result of access to privately-raised capital which is often complemented by government provided finances and technical advice. Private sector investments tend to focus on processing infrastructure while the government focuses on more broadly required community infrastructure requirements (highways, schools, communication systems).

Issues and Trends

The literature identifies a number of major issues and trends involving infrastructure capacity as related to the forest sustainability and conservation. Consider the following (Aschauer 1991a and 1991b, Fox 1987, General Accounting Office 1992, Lewis and others 1993, Munnel 1990, Roundtable on Sustainable Forestry 1999, Sears and others 1990, Forest Service 1997, 2000a and 2000b, Vangh 1984).

- Traditional definitions and concepts of infrastructure are increasingly being challenged as to their relevance to forest sustainability. Notions of infrastructure encompassing physical structures such as roads, buildings, processing facilities, and communication systems are becoming more inclusive to include notions of green infrastructure (ecosystems filtering pollutants and providing aesthetic, recreation, and spiritual qualities), infrastructure facilities that disperse, transform or store residuals that are by-products of economic activities (storage of toxic materials), and infrastructure facilities that focus on objectives not previously considered (campgrounds, ski lifts, recreational trails).

- Benefits provided by infrastructure are increasingly being acknowledged as very diffuse, making it extremely difficult to determine market values for many current or proposed public investments in infrastructure. Furthermore, the benefits from public investments in infrastructure are often only loosely connected to the prices users pay for them. In some cases, users pay no direct clearly-discernable fee for the use of certain infrastructure (for example, hunters, recreationists and the like usually pay no explicit fee for use of public forest roads and trails). The results of these conditions are frequently significant distortions in important economic relationships and subsequent investment decisions.

- Public investments in forest and related infrastructure as a clear cause of augmented economic development and private sector productivity are increasingly being viewed with skepticism. Substantial uncertainty often exists over this relationship; in some cases the relationship is suggested as exaggerated. Such results in serious questions about government's role (in contrast to private sector roles) in fostering infrastructure investments consider necessary for certain forest uses and management activities.

- Specifying appropriate levels of public investment in infrastructure is increasing being viewed as a major challenge. In large measure the problem stems from the reality that in a forest sustainability context such determinations are often made without benefit of a market system that establishes appropriate levels of pricing. Unlike a private firm -- which can compare revenues with costs and adjust output capacity to where marginal cost equals marginal revenue -- the production of forest infrastructure by government is seldom subject to these market mechanisms.

- Appropriate types and levels of investment in infrastructure are increasingly being clouded (made uncertain) by intense political debates over the use, management, and protection of forests. Examples are issues involving the extent to which roads should be built and maintained on public forests and the extent to which economic development (often in the form of wood processing facilities) should be allowed to occur in forested areas. The issue is especially concerning for public lands which often face multiple, shifting, and contradictory objectives for forest sustainability.

- Expected demographic changes are likely to have a significant impact on the type and intensity of forest infrastructure required in the future. Preferences for some forest uses (certain recreation activities) may dramatically change as population structure changes (aging population) or as population density declines in certain forested regions while it increases in other regions.

- Maintenance of existing infrastructure continues to be a concern for both public and private sectors. For the public sector, backlogs in maintenance of roads, trails, bridges and dams are well documented. Compounding the problem is the need to decommission roads on some public forests. In the private sector, aging processing facilities and the advent of new technologies is placing greater stress on private sources of capital for needed improvements in infrastructure.

- Permanent installations as a focus (often limiting) of infrastructure is increasingly viewed as biasing investments away from investment in forest ecosystems where minimal investment in infrastructure may have considerable value (unroaded forest areas, unobstructed scenic forest vistas). Sentiments for minimal, if any, permanent physical infrastructure is of increasing interest to some segments of society that find forest benefits diminished by the presence of physical infrastructure. Such is a reflection of broader contradictions in the type and amount of forest infrastructure required to meet desired needs.

Information Adequacy

Specification

The diversity in form and function of infrastructure raises many questions about information required to adequately assess infrastructure conditions considered necessary to forest sustainability and conservation. In a strategic sense there are a number of information concerns that need to be addressed. For example, there is a pressing need for information about the *status and condition of infrastructure* (magnitude and extent of current and planned capital outlays in infrastructure), *need for investment in new or existing infrastructure* (identification of desired objectives and assessment of infrastructure investments to accomplish them), *processes by which infrastructure is provided* (determinations of adequacy, assessment of needed investments, identification of financial sources, designation of responsibility for

implementation), *effectiveness and efficiency of infrastructure investments* (relationship between desired conditions of forest sustainability and type and level of infrastructure), *knowledge and information networks* (communication and information flow between users and providers of infrastructure), *regional and national influences on infrastructure* (in contrast to local conditions, influence of broader geographic forest conditions, population structure, type and mix of industries, financial capital, research and education resources), and *regional and international comparisons* (determination of infrastructure deficiencies, focusing of public and private investments, learning experiences improving program efficiency) (Lewis and others 1993).

Information about infrastructure considered important to forest sustainability and conservation has received very limited attention by public and private organizations. Notable providers are Federal agencies (for example, U.S. Bureau of Census), most of which focus on infrastructure required for industrial production (including wood-based production). In 1999, the National Association of State foresters (1999) sought a better understanding of State forestry agency information concerning infrastructure. The association reported that only 14 States had access to such information while 36 had no data on the subject. Of the 14 States with information, 3 indicated an abundant amount of information, 7 sufficient information, and the remainder had some but generally very little amounts of information. As for the quality of information about forest infrastructure, 2 States reported it was excellent, 11 adequate, and 2 reported poor quality information (National Association of State Foresters 1999).

Although certainly not exhaustive, the following are more specific directions which might prove useful to a better understanding the role of infrastructure in forest sustainability and conservation and the institutional capacities needed to effectively exercise that role.

- *Measurement Information* — Information about which variables and how they should be measured so as to accurately portray conditions involving forest infrastructure has not been assembled (What indicators should be measured and subsequently compiled [for example, road density per unit area, roads per capita]? What infrastructure indicators are most appropriate for various standards of sustainable forest management [for example, campgrounds, trails, educational facilities, timber management]? How often are these indicators to be measured? Are there special indicators and measurement needs associated with different type of infrastructure or for public versus private infrastructure? What is an appropriate indicator of necessary infrastructure [for example, appropriate standards for roads, processing facilities]?)

- *Extent of activity information* – Information about infrastructure is often scattered and uneven among public and private collecting organizations, the result of which is information that lacks local, regional, and national consistency (What are the

legal requirements for investing in infrastructure at various geographic levels and by various organizations? How are these requirements changing over time [if at all]? Are there differences in requirements at different levels of government? Is there consistency across these requirements? What is the status of local efforts to encourage infrastructure development? What is the condition of private infrastructure and extent of private investment in such infrastructure? How does current infrastructure relate to public and private forest plans, What portion of infrastructure is being managed to some agreed-to designated standard? Are compilations as currently carried out useful for guiding policy and program direction?).

- *Responsible Organization Information* — Information about what private and public organizations are actively engaged in the development and maintenance of forest and related infrastructure has not been assembled except in a very modest way (What government agencies, and at what levels, are engaged in infrastructure development and maintenance [for example, Forest Service, U.S. Department of Transportation, U.S. Geologic Survey, State and local governments, industrial forest land owners]? What legal authority assigns them responsibility and is such authority being accurately interpreted? Should certain governments [local governments] be responsible for providing infrastructure for certain forest landowners [nonindustrial private forests]? Do public and private organizations engage in infrastructure development have similar or differing goals and objectives that foster or hinder needed investment in infrastructure? Are there organizational patterns in the public and private sector that, if known and publicized, would enhance overall investment in infrastructure?)

- *Coordination information* – Information about requirements to coordinate development and maintenance of infrastructure among and between various levels of government and various private concerns has not been assembled (What conflicts exist between the various entities engaged in developing and maintaining forest infrastructure? How might they be productively resolved? What are requirements for coordination? Do they allow for cross-sectoral, coordinated planning and review [for example, road systems involving multiple forest ownerships]? Do they ensure that the cumulative results of local, State, and regionally developed infrastructure will lead to outcomes consistent with national requirements and vice versa? Do they allow incorporation of ad hoc code development activities occurring at various times and undertaken by various levels of government?).

- *Scope of Infrastructure Information* — Information about forest infrastructure in addition to that required for wood production and processing has not been comprehensively assembled (What infrastructure has been developed for the range of values associated with forests? What approaches have been used to encourage development and application of this broader range of infrastructure needs? What legal requirements are there that require development of infrastructure for the broad range of values associated with forests? Do these legal requirements differ among

agencies at the same level of government and between levels of government? Are these differences complementary or competitive? Are their barriers to developing infrastructure in addition to those focused on wood production and processing? If so, how might they be overcome?)

- *Investment and Incentive Information* – Information about resources devoted to infrastructure development and maintenance has not been comprehensively assembled except in some very limited cases (What is the magnitude of investment in public and private infrastructure? Is there an appropriate level of investment in new infrastructure [percent of existing infrastructure]? Are there legal and administrative processes for allocating resources to infrastructure development and maintenance [are they sufficient]? Are there provisions [legally or fiscally] for encouraging infrastructure development, especially encouraging cross-sectoral development and maintenance activities?).

- *Effectiveness information* — Information about the effectiveness of various types and levels of infrastructure and abilities to accomplish sustainable forestry interests has not been compiled except in some very limited cases (Are there legal or administrative requirements to determine efficiency and effectiveness of infrastructure development? What are appropriate measures of success? Are there more effective approaches to accomplishing infrastructure development and maintenance?).

- *Monitoring information* — Monitoring the condition of forest infrastructure and levels of investment therein has been carried out by some (notably Federal agencies) but could be improved (Are their legal requirements to monitor the condition of forest infrastructure? Is this information from monitoring activities being used to adapt infrastructure investments to changing circumstances? Is the information being collected and analyzed in such a way to be useful to fulfilling legal requirements assigned to an agency? Are the results of monitoring efforts capable of being accumulated to portray sound representation of conditions at the landscape, regional and national levels?).

Recommendations

The ability to influence forest sustainability will depend a great deal on consistent, long-term investments in appropriate types of infrastructure as suggested by Indicator 56. In order to improve understanding of the legal and institutional setting within which such will occur, there are a variety of information voids that need to be addressed (many described directly above). In order to suitably deal with them, the following actions would seem appropriate.

- *Comprehensive periodic reviews.* Conduct periodic and comprehensive reviews of current authorities (and institutions) that give direction and resources to the physical infrastructure considered necessary for forest sustainability. Guided by the

above suggested information deficiencies, the reviews should give special attention to the collection of information about the type and extent of infrastructure, organizations responsible for ensuring appropriate levels of infrastructure, and the long-term appropriateness and effectiveness of forest infrastructure. This information should be gathered to the extent it occurs at Federal, State, and local levels of government. In addition, a systematic review of private sector capability to foster appropriate infrastructure should also be initiated.

- *Responsibility for conducting reviews.* Assign responsibility for conducting reviews (on a continuous basis) of forest infrastructure to a specific (current or new) administrative unit located within a Federal agency (Forest Service's State and Private Forestry or Research and Development), a college or university, or other nonprofit organization (for example, National Association of State Foresters, National Council of the Paper Industry for Air and Stream Improvement). This responsibility should be assigned to an organization that has a proven track record in addressing the complexities of forest infrastructure.

- *Devote resources to reviews.* Invest in the review sufficient resources as are necessary to provide the type and quantity of information necessary to dramatically improve understanding of current abilities to plan, construct, and maintain forest infrastructure considered important to sustainable forestry.

Indicator Appropriateness

Indicator Definition

Unclear definition of the activities specified by Indicator 56 are bothersome, especially the elusiveness of the indicator's major descriptive words and phrases, such as "physical infrastructure," "facilitate supply of forest products and services," and "support for forest management." These words or phrases supposedly embody an agreed to set of concepts and principles around which information gathering efforts can take place. Such is not always the case as is highlighted by the need to set forth definitions earlier in the information review for this indicator. The problem is further complicated by clashes in the use of old terms (such as "public works") and new terms (such as "green infrastructure") that are used to portray perceptions of infrastructure. Lacking a clear understanding and definition of Indicator 56 makes the exercise of determining legal capacity to ". . . develop and maintain efficient physical infrastructure. . . ." difficult at best and the products of compilations of questionable value.

The scope of subject matter to which this indicator is to be addressed is also of concern. The dilemma rests in the reality that physical infrastructure can be inclusive of least four basic elements, namely forest ecosystems as infrastructure, forest land base infrastructure (roads, recreation facilities), forest product processing

infrastructure (manufacturing facilities), and broad forest community infrastructure (schools, hospitals). Although these distinctions are not discrete by any means, they are descriptors that will drive information gathering for this indicator. Some have suggested the indicator be limited to “infrastructure related to implementation of forest plans and capital investments in the management and protection of the forest land base (for example, forest roads, recreation facilities). While germane, larger scale infrastructure systems (for example, mills, production facilities, public/freight transportation systems [highways, trains, boats], energy/water infrastructure, financial/banking systems) are deemed to be beyond the scope of this indicator” (Roundtable on Sustainable Forestry 1999). Such an approach would make the information gathering task much easier. However, to limit interpretation of the indicator in such a way would severely constrain efforts to appreciate and understand the importance of infrastructure (in its broadest sense) to forest sustainability and conservation.

Although infrastructure scope and definition problems will continue to be troublesome, a suggested more useful, all-encompassing wording for the indicator is institutional capacity to “. . . *Develop and maintain physical infrastructure necessary to manage and protect forests and to make available the range of goods and services that forests are capable of providing.*”

Cross-Cutting Conditions

Crosscutting issues involving Indicator 56 are frequent, particularly as they relate to concepts involving development and implementation of forest management plans. Among the potentials for difficulty in this respect is Indicator 56's relationship to Indicators 10 (area of forest land), 35 (area of recreation forest land), 36 (facilities available for recreation and tourism), 38 (investment in forests and product processing), 42 (forest land spiritual values), 46 (changing economic conditions), 49 (planning and assessment), and 54 (planning and coordination). Such are obvious sources of crosscutting implications for Indicator 56. There may be other indicators that are also relevant in this respect.

Literature Cited

- American Forest and Paper Association. 2000. Paper, Paperboard and Wood Pulp Statistics 2001. Washington, DC.
- Aschauer, D. A. 1991a. "Infrastructure: America's third deficit." *Challenge* 34(2): 39-45.
- Aschauer, D. A. 1991b. "The Third Deficit." *GAO Journal* Spring 1991: 4-8.
- Betz, C. J. 1998. Outdoor Recreation Supply in the United States: A Description of the Resources, Data, and Other Information Sources. Southern Research Station. Forest Service. Asheville, NC.
- Betz, C. J., D. B. K. English, and H. K. Cordell. 1999. Outdoor Recreation Resources. In: *Outdoor Recreation in American Life* by H. K. Cordell and S. M. McKinney (ed. Pg 39-182. Sagamore Publishing. Champaign, IL.
- Council of State Governments. 2000. *The Book of States: 2000-2001*. Volume 33. Lexington, KY.
- Cordell, H. K. 1999. Framework for Assessment of Demand and Supply Trends in Outdoor Recreation. In: *Outdoor Recreation in American Life* by H. K. Cordell and S. M. McKinney (ed). Pg 31-38. Sagamore Publishing. Champaign, IL.
- Betz, C. J. 1998. Outdoor Recreation Supply in the United States: A Description of the Resources, Data, and Other Information Sources. Southern Research Station. Forest Service. Asheville, NC.
- Betz, C. J., D. B. K. English, and H. K. Cordell. 1999. Outdoor Recreation Resources. In: Outdoor Recreation in American Life. Pg 39-182. Sagamore Publishing. Champaign, IL.
- Ellefson, P. V., R. J. Moulton, M. A. Kilgore. 2001. Programs and Organizations Affecting the Use, Management, and Protection of Forests: An Assessment of Agencies Located Across the Organizational Landscape of State Governments. Department of Forest Resources. University of Minnesota. St. Paul, MN.
- Ellefson, P. V., R. J. Moulton, M. A. Kilgore. 2002. An Assessment of State Agencies the Affect Forests. *Journal of Forestry* 100(6):35-42.

Fox, William F. 1987. "Public Infrastructure and Economic Development." In: *Rural Economic Development in the 1980's: Preparing for the Future*. Pg 13-1 - 13-23. Division of Agriculture and Rural Economy. USDA Economic Research Service. Washington, DC.

General Accounting Office. 1991. Forest Service: Difficult Choices Face Future of the Recreation Program. GAO/RCED-91-115. Washington, DC.

General Accounting Office. 1992. Rural Development: Rural America Faces Many Challenges. GAO/RCED-93-35. Washington, DC.

General Accounting Office. 1995. National Parks: Difficult Choices Need to be Made About the Future of the Parks. GAO/RCED-95-238. Washington, DC.

Lewis, B.J., P. V. Ellefson, and R. J. Moulton. 1993. Public Infrastructure and Rural Development in Forested Areas of the Lake States: A Review and Assessment of Information Needs. Staff Paper Series No. 90. Department of Forest Resources. University of Minnesota. St. Paul, MN.

Munnell, A. H. 1990. "How Does Public Infrastructure Affect Regional Economic Performance?" *New England Economic Review*. (Sept.-Oct. 1990): 11-32.

National Association of State Foresters. 1999. First Approximation Assessment Report. Washington, DC.

Presidential Executive Order. 1994. Principles for Federal Infrastructure Investments. Executive Order 12893 of January 26, 1994. Federal Register Volume 59 Number 20. Washington, DC.

Roundtable on Sustainable Forestry. 1999. Criterion Level Summary: Indicator 48-59. Criteria Technical Committee. Washington, DC.

Sears, D. W, T. D. Rowley, and J. N. Reid. 1990. "Infrastructure investment and economic development: An overview." In: *Infrastructure Investment and Economic Development*. Pg 1-18. AGES 9069. Division of Agriculture and Rural Economy. USDA Economic Research Service. Washington, DC.

Teasley, D. W., J. C. Bergstrom, H, K, Cordell, S. J. Zarnoch, and P. Gentle. 1999. Private Lands and Outdoor Recreation in the United States. In: *Outdoor Recreation in American Life* by H. K. Cordell and S. M. McKinney (ed). Pg 183-218. Sagamore Publishing. Champaign, IL.

U.S. Census Bureau. 2000a. Annual Survey of State and Local Government Finances. Department of Commerce. Washington, DC.

U.S. Census Bureau. 2000b. *Statistical Abstract of the United States*. Department of Commerce Washington, DC.

U.S. Census Bureau. 2001a. General Summary 1997 Economic Census Manufacturing (Subject Series). EC97M31S-GS. Department of Commerce Washington, DC.

U.S. Census Bureau. 2001b. Annual Capital Expenditures: 1999. ACE/99. Washington, DC.

U.S. Department of Agriculture. 1990. Infrastructure Investment and Economic Development. AGES 9069. Division of Agriculture and Rural Economy. USDA Economic Research Service. Washington, DC.

Forest Service. 1997. Criteria and Indicators: First Approximation Report. Washington, DC.

Forest Service. 1999. Report of the Forest Service: Fiscal Year 1999. Washington, DC.

Forest Service. 2000a. Forest Service Roadless Area Conservation. Final Environmental Impact Statement (Vol 1). Washington, DC.

Forest Service. 2000b. Northeast Area Forest Sustainability Report (draft). Northeast Area. State and Private Forestry. Newtown Square, PA.

USDI National Park Service. 2000. National Park Service Statistical Abstract. Washington, DC.

Vanghn, R. J. 1984. "Rebuilding America: Financing Public Works in the 1980s." In: *Rebuilding America's Infrastructure: An Agenda for the 1980s* by M. Barker (ed). Pg 108-120. Duke University Press. Durham, NC.